PHOTOVOLTAIC ENERGY HARVESTING CIRCUIT FOR POWER DEVICES

A thesis submitted in partial fulfilment of the requirement for the degree of

Bachelor of Technology

in

Electrical Engineering

by

Ayush Singh (111EE0234)

Manaranjan Dalai (111EE0205)

Subhendu Nayak (111EE0251)

Under the guidance of

Prof. Bidyadhar Subudhi

Department of Electrical Engineering

National Institute of Technology Rourkela

Rourkela- 769 008, Odisha, India.

DEPARTMENT OF ELECTRICAL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY, ROURKELA
ODISHA, INDIA, 769 008.

Date- 11th May, 2015

CERTIFICATE

This is to certify that the thesis entitled "**Photovoltaic Energy Harvesting Circuit for Power Devices**", submitted by **Ayush Singh (111EE0234), Manaranjan Dalai (111EE0205) and Subhendu Nayak (111EE0251)** in partial fulfilment of the requirements for the award of Bachelor of Technology in Electrical Engineering during session 2014-15 at National Institute of Technology, Rourkela. A bonafide record of research work carried out by them under my supervision and guidance.

The candidates have fulfilled all the prescribed requirements.

The Thesis which is based on candidate's own work, have not submitted elsewhere for a Degree/diploma. In my opinion, the thesis is of standard required for the award of a Bachelor of Technology degree in Electrical Engineering.

Place: Rourkela

Prof. Bidyadhar Subudhi
Professor
Dept. of Electrical Engineering

ACKNOWLEDGEMENT

On the submission of our thesis entitled “Photovoltaic Energy Harvesting Circuit for Power Devices”, we would like to extend our gratitude & our sincere thanks to our supervisor

Prof. Bidyadhar Subudhi, Professor, Department of Electrical Engineering for his constant motivation and support during the course of our work in the last one year. We truly appreciate and value his esteemed guidance and encouragement from the beginning to the end of this thesis. His knowledge and advice at the time of crisis would be remembered lifelong.

We are very thankful to all our teachers especially Prof. A. K Panda for providing solid background for our studies and research thereafter. They have been great sources of inspiration to us and we thank them from the bottom of our hearts.

We also would like to thank the staff of Electrical engineering department for constant support and providing place to work during project period.

At last we would like to extend our gratitude to our family and friends, and would like to dedicate this project to them for their help, patience and understanding.

Ayush Singh (111EE0234)

Manaranjan Dalai (111EE0205)

Subhendu Nayak (111EE0251)

ABSTRACT

As an ideal solution to the great energy crisis that exists, a Photo Voltaic (PV) energy system is becoming more popular by the day, especially since the economic consequences for such solution are improving every day. Replacing conventional sources would require such systems to be highly efficient and user friendly. Proper functioning and practical application of this system requires precise control over voltage and current to deliver energy without affecting the mobile device. A solar based mobile charger is one such system which is used to recharge modern day smartphones. In this project, we have designed and developed a prototype of a Photo-Voltaic energy harvesting mobile charger which comprises of a Buck converter which is used to synthesize and modulate the DC power harvested from the PV module to suit the specific load requirements of a mobile phone. The system also consists of a controller which uses LM 2575 to charge the battery optimally. Proposed system is first simulated in the MATLAB-Simulink and then practically implemented to verify the theoretical results. The buck converter's open loop control is achieved through ICs.

CONTENTS

LIST OF FIGURES

ABBREVIATION & ACRONYMS

PV	Photo-Voltaic
MPPT	Maximum Power Point Tracking
PDA	Personal Data Assistant
P&O	Perturb and Observe
PVA	PV Array
IC	Integrated Circuit

1. INTRODUCTION

The term "photovoltaic" comes from the Greek φῶς (phōs) meaning "light", and from "volt", the unit of electro-motive force, and the volt, which in turn comes from the last name of the Italian physicist Alessandro Volta, and inventor of the battery. The term "photo-voltaic" has been in use in English since 1849.

It can be assumed from simple observations that the professional and personal lives of modern day human being comprises heavy use of mobile devices, from laptops, tablets or smartphones. The varying interactive multimedia services that these devices provide are slowly becoming necessities in everyday life. Hence, it is obvious that this has led to increase efforts in finding power solution for these devices that is efficient and user friendly, and since conventional sources slowly getting depleted, an ideal solution for this efforts would be to have a charger with greater mobility and economically cheap. Thus, emerges the need to develop autonomous energy sources and systems to replace the traditional batteries which charges from AC adapters. To achieve these lofty expectation the charger must be very precise to the need of modern day consumer.

In order to replace conventional sources, the most efficient replacement would be to use Photo-Voltaic energy to charge these mobile devices. Photo-Voltaic or PV uses solar cell to achieve to direct conversion of sunlight into electricity. Present application of this mode includes generating energy to power remote sensing applications such as wireless sensor nodes.

One of the most effective model to implement a PV system comprise of two separate DC-DC Converters, one converter is used to execute the MPPT (Maximum power point tracking) whereas the other is used as voltage regulator to deliver the most precise voltage to the load (in this case a smartphone).

We will discuss the above mentioned operations in great details a bit further down this paper. Also we would show the implementation of DC-DC converter to achieve our targets.

1.1 Motivation

Even though Solar based chargers for various devices exist in the market, their poor performance and various practical limitations have deemed them to be unpopular among the consumers. Further, many such charge system lacks precision which is key to deliver charge to modern day smartphones.

Some designs such as Fold-Out have been effective. It can charge phones in 3 hours by allowing higher charge current while also maintaining a compact size. Solar Chargers are used for variety of devices like speakers, Bluetooth headsets etc.

We have tried to stay on the path of optimization by managing different limitation and also charging the device in a feasible time.

Our final prototype consist of a small charge panel and associated circuitry to eliminate the need to switch off the PV Cells, while also charging the phone through an output from a DC-DC converter. Our design should be able to achieve the final target of charging the smartphone or any other local phones in 10-12 hours of direct sunlight.

Also, our design enables the solar panel to be angled at 45^{o} to the surface, in order to get the maximum photons throughout the day without changing the arrangements. This ensure a good amount of sunlight to be projected at the panel.

1.2 Solar Power in India

India has an enormous potential to harvest solar energy. As a tropical country it has around 300 sunny and clear days in a single year. That amounts to 5000 trillion kWh per year. The incidence of solar energy on a daily average is 4 to 7 kWh/m2.

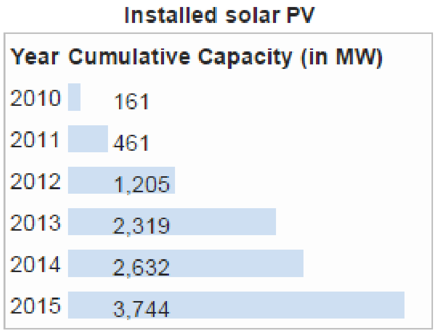


Figure 1 Installed Solar Capacity in India (Year wise)

1.3 Solar Based Mobile Charger

As a replacement to conventional sources, solar cells are used mainly in those application which are very much exposed to the outdoor and in turn exposed to the sunlight. Such applications include public street lamps and charge outlets at public places such as streets, park and squares. Some mobile phone companies have even tried to emulate solar panels in the body of the product in order to power the mobile phone batteries, but poor efficiency and frequent maintenance problem have resulted in poor sales in market.

Some of the Shapes in which Solar Cell phone chargers are available in are-

1. Folded – Offers good portability
2. Rotating – To maximize the intensity of solar rays
3. Straps – Outer surface has the solar cell and the inner surface has the nickel metal hybrid battery.

1.4 Design Principle

During this paper we will go into greater detail about the complete design of the module especially that of the Solar Panel and the DC-DC converter that we have designed using LM 2575. Briefly, it is very important to ensure good battery life and performance while designing the circuit. Solar panel are rated at 15 W or more, to charge battery and to deliver the required power to the mobile phone we will use a controller which will regulate voltage. There is also a risk of overcharging the battery if the duration of intense sunlight lengthens. The controller also ensure that no such situation arises. The panel in connected to a voltage controller which in turn is connected to battery and the arrangement goes through a buck converter to provide suitable output for charging.

1.5 Objective

This project will comprise of four objective which collectively results in formation of the PV Charger module. These objectives are-

1. PV Modelling
2. Understanding the MPPT Algorithm
3. Designing a Prototype
4. Implementation and final result.

2. PROPOSED WORK

2.1 Overview

Solar based mobile phone chargers use solar powered boards to charge cell batteries. They are a different option for traditional electrical phone chargers and now and again can be connected to an electrical outlet. There are likewise open solar based chargers for cellular telephones which can be introduced for all time openly places, for example, boulevards, stop and squares. A few models of mobiles have an implicit solar powered charger and can be industrially accessible for normal mobile phones. Solar based PDA chargers are available in distinctive shapes and arrangements comprising collapsing and pivoting sorts. They additionally come as straps, with solar based cells on the external surface and a nickel metal hydride battery inside. Current solar powered cell innovation confine the viability and reasonableness of telephone solar light based chargers for ordinary utilization. Telephone charge times shift relying upon the battery limit introduced which keeps on expanding, further augmenting the charge times of solar oriented chargers. The fold-out outline has demonstrated to take into consideration higher charge current while keeping up a conservative size and current outlines are fit for charging a current day cell phone in 3 hours. Solar based chargers are additionally accessible for other PDA embellishments, for example, bluetooth headsets and speaker telephones.

This energy generation framework comprises generally of limits underneath 100W. They have an immense scope of uses running from controlling adding machines, instructive toys, solar oriented lights, movement signals, portable chargers, and so forth. They are generally comprised of poly crystalline material of solar powered cells because of their higher energy thickness over a little region and fits in the compact applications. On the other hand, this framework is not exceedingly marketed because of battery innovation needed to store the force produced and high cost of poly crystalline silicon solar based cells. They by and large utilize lithium particle batteries to store energy because of its high energy limit and light in weight.

These frameworks come convenient when force is needed on move and can possibly alter the current time of gadgets with free power on move. The straightforward versatile charger in light of PV energy framework comprises of a little solar oriented module by and large made of poly crystalline silicon, associated with the electrical load through a buck converter for regulation of voltage at the load end. This regulation is typically done utilizing a feedback loop that detects the output voltage and tries to keep it at the wanted output voltage needed.

We outlined here a small charger board and the related hardware to wipe out the need to cut the solar oriented cells, getting the suitable voltage and force yield through a DC-DC converter. We outlined a last model that ought to have the capacity to charge any of the ordinarily utilized nearby telephones as a part of 10-12 hours of direct daylight.

2.2 Problem Statement

1. Photo voltaic cell simulation and modelling.
2. Maximum Power Point Tracking by Perturb & Observe algorithm to find out the operating voltage of the module.
3. Designing of a DC/DC Boost Converter.
4. Designing of a Battery Protection Circuit
5. Designing a charge pump circuit.

2.3 Framework to the Solution

We will approach the solution the section as mentioned in the problem statement. Our first objective is to study the photovoltaic cells. We will go through these one by one as follow.

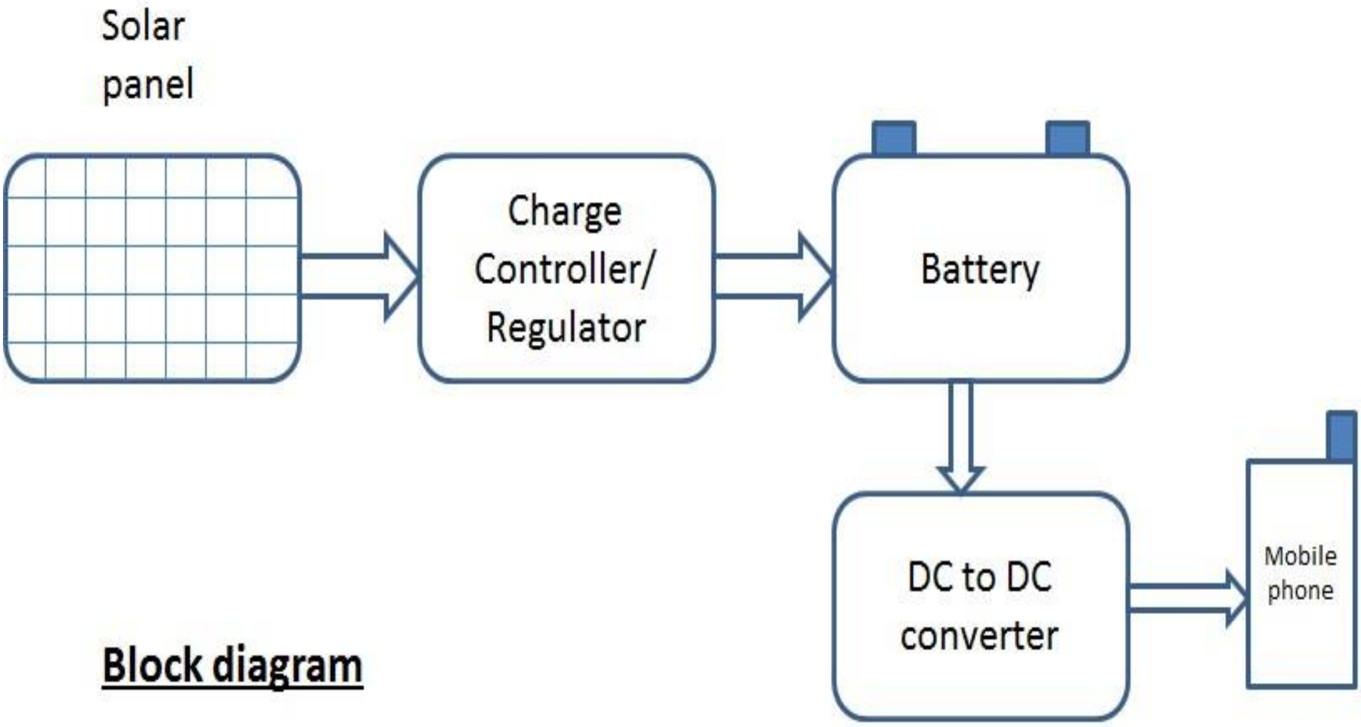


Figure 2- Block Diagram of a Solar Mobile Charger.

2.4 PV Cell

2.4.1 PV Cell Basics

A photo-voltaic cell harvest the energy stored in photon (which are essentially packets of light filled with energy). When connected to an external, the cell creates a potential difference thus driving the current in the circuit which can be delivered to load connected to the circuit.

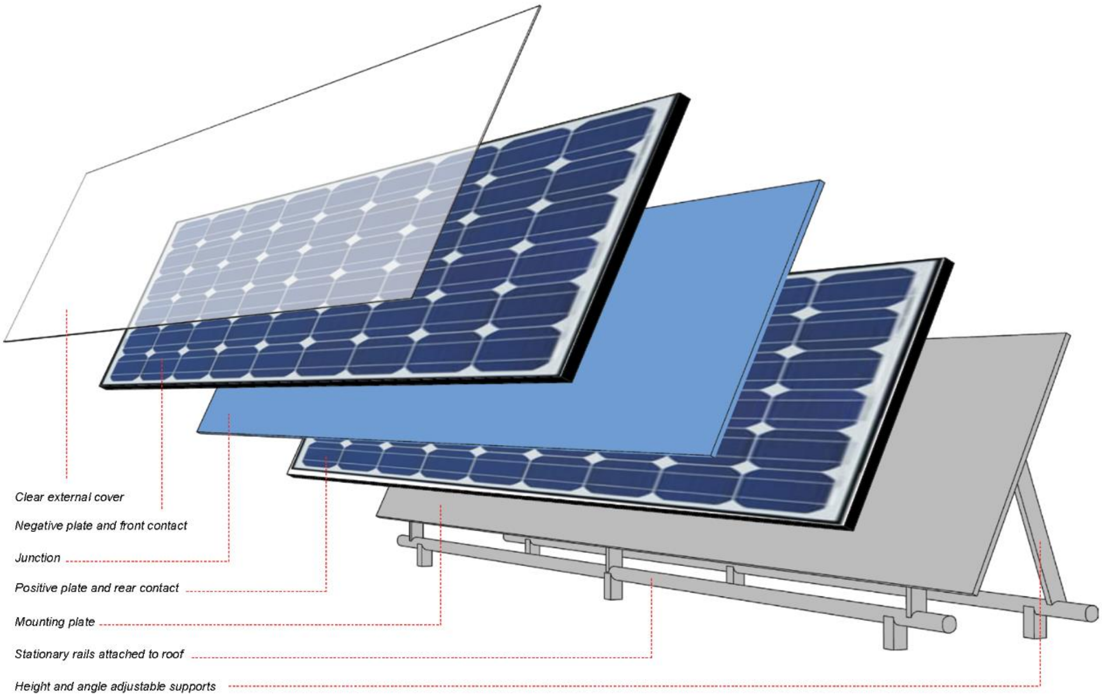


Figure 3 Photovoltaic Cell (Layer by Layer)

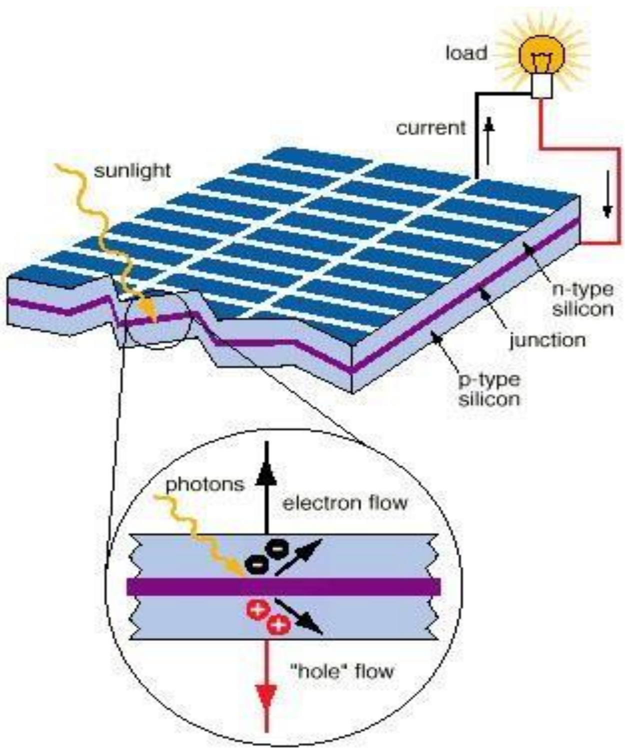


Figure 4 Photoelectric Effect on Solar Cell

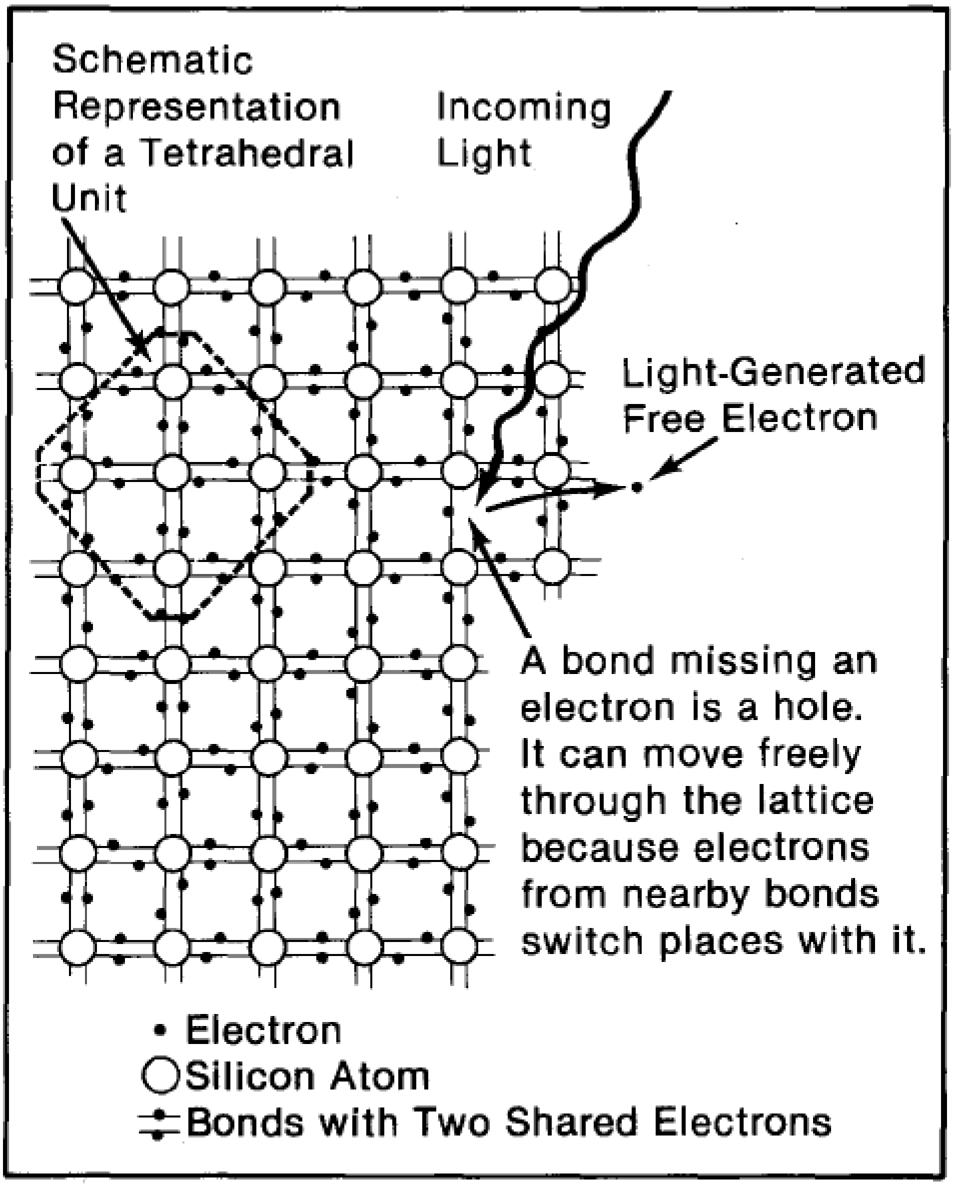


Figure 5 Light of sufficient energy can generate electron-hole pairs in silicon, both of which move for a time freely throughout the crystal

The level of energy harvesting that can be done from a PV Cell depends on following factors-

1. Material type and Size of the PV Cell
2. Solar Intensity
3. Wavelength of Solar rays (Λ)

2.4.2 PV Cell Design

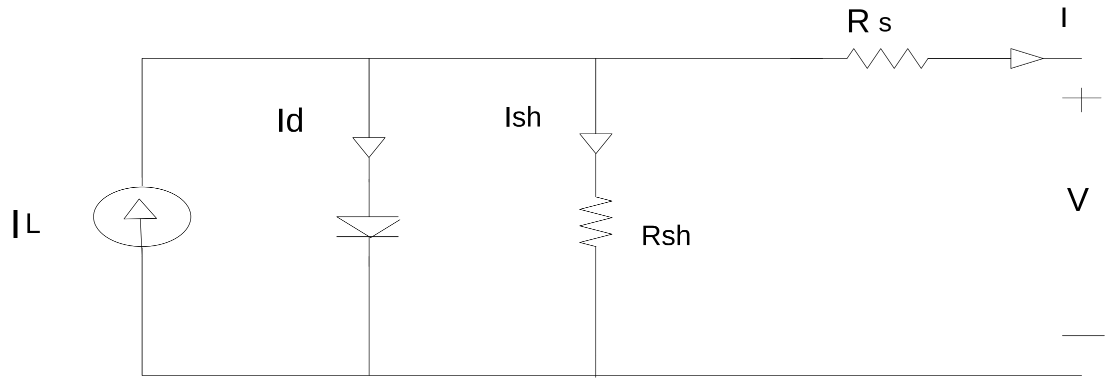


Figure 6 PV Cell Model

A simple existing classical model of PV cell is given in the Fig. Common simulating tools are used for the approximated equivalent circuit as given in figure above in order to simulate all electric circuits which contain diodes.

V_{pv} = O/P voltage of a PV module (V)
I_{pv} = O/P current of a PV module (A)
T_r (reference temperature) = 298 K
T = module operating temperature (K)

I_{ph} = light generated current in a PV module (A)
I_o = PV module saturation current (A)

A = B = 1.6 (ideality factor)

k = 1.3805×10^{-23} J/K (Boltzman constant)
q = 1.6×10^{-19} C (charge on an electron)
R_s = series resistance of a PV module
I_{SCr} = 2.55A (PV module short-circuit current at 25 ^oC and 1000W/m^2)

K_i (short-circuit current temperature co-efficient at I_{SCr}) =0.0017A/^oC
λ (PV module illumination) = 1000W/m^2
E_{go} (band gap for silicon) = 1.1 eV

N_s = number of cells connected in series

N_p = number of cells connected in parallel

2.4.3 MPPT Algorithm

The different type of algorithm used for MPPT are

- Perturb and observe
- Incremental conductance
- Current Sweep Method

Controllers are generally used to following one of these methods to optimize the output power of an array. Maximum power point trackers can device different algorithms and switch in between them based on condition of operation of the array. Because of simplicity Perturb and observe algorithm is implemented in this project work.

Perturb & Observe:

During the execution of this method, the voltage regulator or controller changes the voltage by a small value from the array and calculates the change in power. If the change in power is positive, the change in voltage in that direction is continued until power doesn't increase anymore. This method is called Perturb & Observe. This can result in oscillation of power output. As seen from Power Vs Voltage graph of a PV Cell, it resembles a hill with a clear which is tha maximum power point and just below that point is the point used for MPPT method. This may result in good efficiency if the execution of the method is proper.

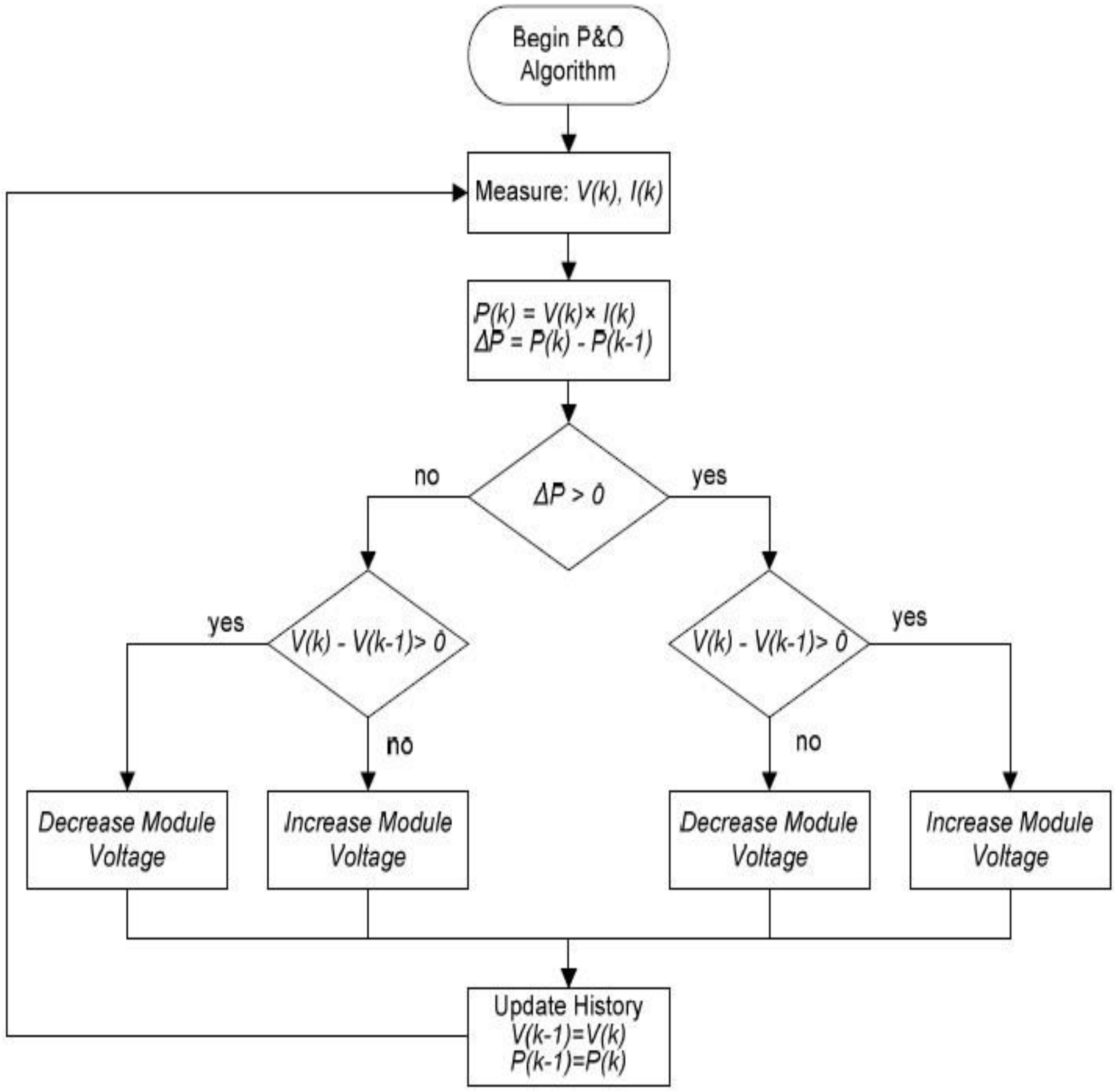


Figure 7 Flowchart of P & O MPPT Technique

2.4.4 Design Principle

When the solar chargers are of 15W or more rating, the use of a controller is recommended. As the battery reaches maximum charge, and still the sun keeps on shining, there is risk overcharging the battery. Solar controllers are essential to regulate the voltage output from the solar panel and check batteries from being overcharged.

The solar panel output connected to a battery through a charge controller. Battery output is connected to a voltage regulator and that output can be used for mobile charging.

2.5 Current and Voltage characteristics of a Solar Cell

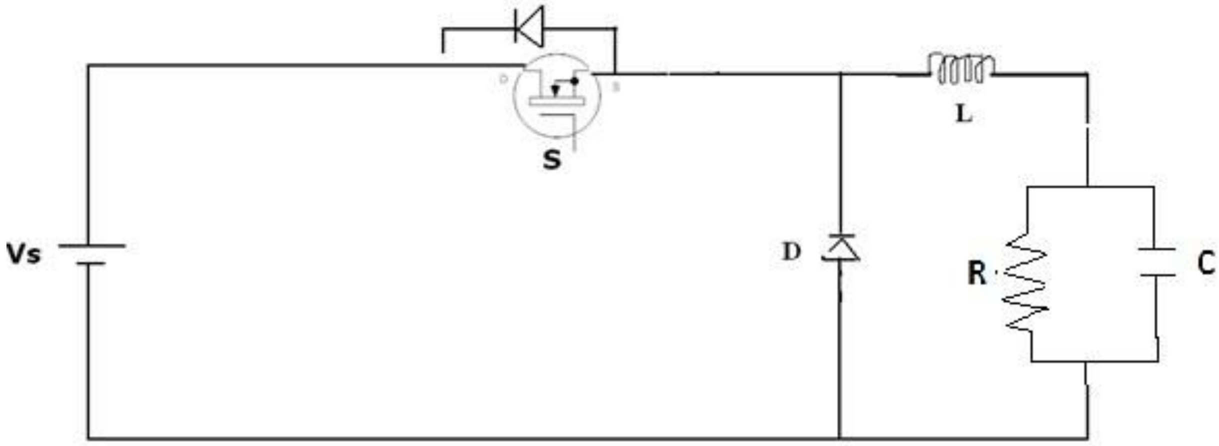
The solar based cell's output characteristics focus power yield from cell under fluctuating load requirement and environmental situations. The output voltage will be a component of surrounding high temperature and drops with increment in the same because of lessening in PN junction's width. The output current will be a component of solar based insolation as higher number of photon push out higher number of electrons and the increment in irradiation on the surface of the cell at a particular temperature, it rises.

For a given arrangement of barometrical conditions, the voltage and current changes with a connection as characterised by the equations above. When the load rises, the voltage reduces and as current is diminished, the voltage increments. Accordingly, there is an existence of a reverse relationship in the middle of current and voltage from PV array and the working point gets modified from V_{OC} at no current to I_{SC} at no voltage. Every one of these arrangements of values yield the output attributes curve. This arrangement of values from the aforementioned mathematical statements is plotted in MATLAB-Simulink environment and the figure demonstrates the simulated result from the arrangement of values.

Additionally, the disparity of the values can be seen for changing sets of temperature and irradiation. Though, the prevailing impact of growing cells temperature is the linear decline in the open circuit voltage, decreasing the cells effectiveness. On the other hand, the output current of the cell increments somewhat with increment in the cell temperature.

The open circuit voltage changes logarithmically and the current directly with the irradiation. Additionally, the changes in power can be seen for barometric conditions for ideal power extraction from the PV panel.

2.6 BUCK Converter



3

4 **Figure 8 Schematic Diagram of Buck Converter**

Buck Converter is otherwise called as Step-down Converter. The voltage through the load is Vs when the MOSFET is in ON state. The path of current across the load is similar to the direction in the figure. And as MOSFET is turned off, the current across the load will be in the direction as earlier but the voltage comes out to be null. The path of power flow starts at source and terminates at load. Hence, the source voltage comes out to be more than the average voltage, which can be calculated from duty cycle of the pulse delivered to the MOSFET.

The load current is smoothened by the use of the inductor and it also converts the current into DC current, the ripples generated in output voltage are minimised by the use of the capacitor and also the supply of a steady voltage is due to it.

2.6.1 Design Parameters

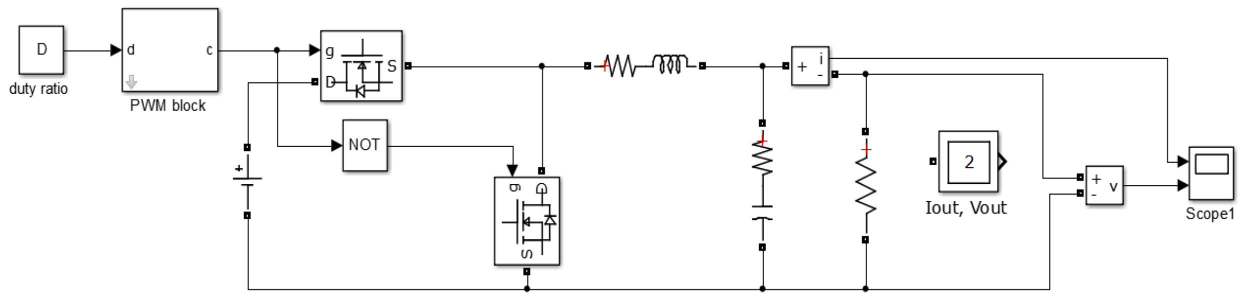


Figure 9 Simulink Block of Buck Coverter

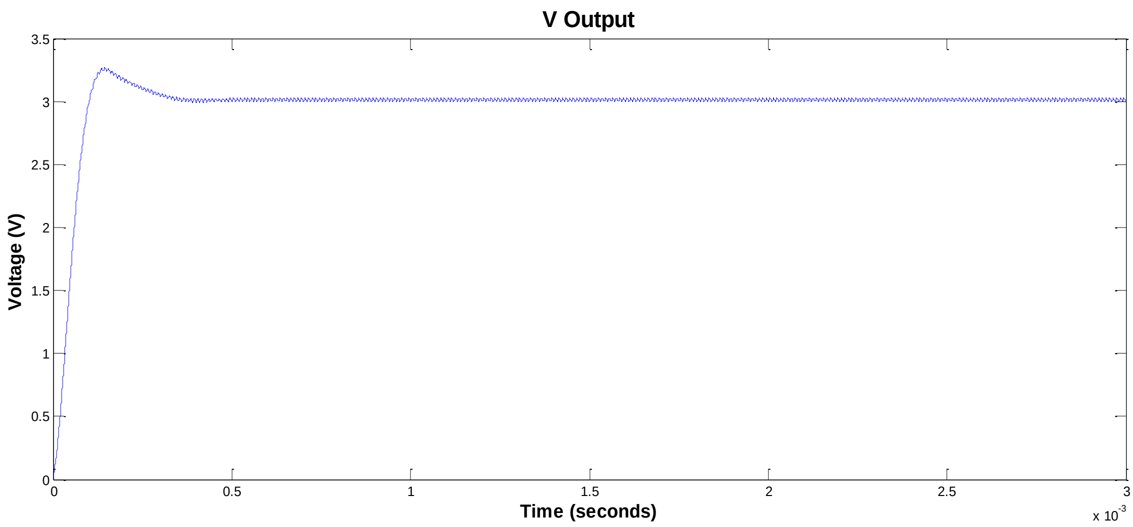


Figure 10 Output Voltage of Buck Converter

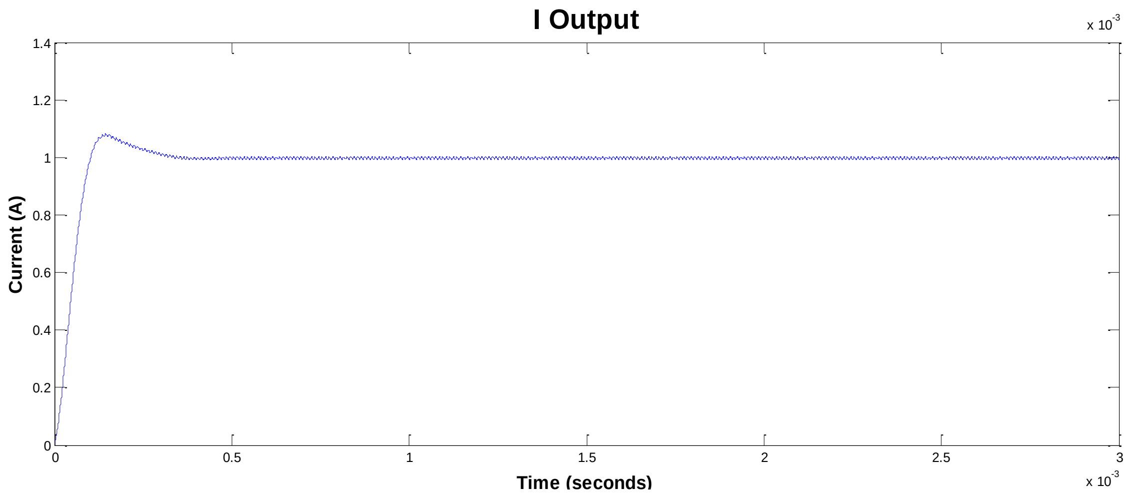


Figure 11 Output Current of Buck Converter

$V_{in} = 12v$

$V_{out=}$3V

$I_{load} = 1A$

Duty cycle (D) = $\frac{V_{out}}{V_{in}}$=0.25v

$I_{ripple} = 0.3 * I_{load} = 0.3A$

Frequency of Switching (F_{sw}) = 200 KHz.

Design of a Buck Converter

Calculation of inductor

$$L = \left(\frac{V_{in}}{V_{out}}\right) * (\frac{D}{F_{sw} * I_{ripple}})$$

$L = (\frac{12v}{3v}) * (\frac{0.25}{200Khz*0.3A})$

L = 16 micro Henry

For designing it practically, 16µH, 2Ampere coil with R=0.05Ω is designated.

I^2R loss is,

$P = I_{load}2$ *esr

P = 1*0.06 = 0.06W

Estimation of the o/p capacitance

$$\Delta v = \Delta I * \left(ESR + \frac{\Delta T}{C} + ESL\right) * \Delta T$$

Ripple V = 50mV

Ripple current = 0.3A

As per the data ΔT is considered as 58µs.

ESL = 0

$$\Delta V = \Delta I * (ESR + \frac{\Delta T}{c}) * \Delta T$$

$$C = \frac{\Delta I * \Delta T}{\Delta V - (\Delta V - ESR)}$$

$$C = 500\mu F$$

To design it practically, capacitor made of polymer having $500\mu F$ and esr = 0.05Ω is considered.

Loss of power comes out to be;

$$P_{loss} = I_{ripple}^2 * ESR$$

$$P_{loss} = 4.5\ mW$$

Estimation of input capacitance

Projected i/p ripple I = $\frac{I_{load}}{2} = 0.5A$

Agreeable i/p ripple V = 200 mV.

esr = 0.12Ω.

$$C_{in} = \Delta T * \left(\frac{V_{ripple}}{esr}\right)$$

$$C_{in} = 96.6\mu F$$

As per the convenience i/p C = 100μF.

Power lost is

$$P = I_{ripple}^2 * esr$$

$$P = 0.0108W$$

Choice of Diode

$$I_D = (1 - D * I_{load})$$

$$I_D = 0.75A$$

For the diode, V_R = 12 V.

Due to the low conduction losses of a Schottky diode, it is the one which is considered.

Loss of power;

$V_F*I_D = 0.4*0.75$

$V_F*I_D = 0.3W$

The predicted V drop = 0.47W.

Selection of the MOSFET

An N-channel MOSFET is considered.

$V_{in} = 12V$

$I_L = 1A$

$T_r = T_f = 55ns$

F_{SW} = 200 KHz

$R_{DS(ON)} = 0.02\Omega$.

Losses due to conduction = $I_D^2 * R_{DS(ON)} * D$ = 5mW.

$$P_{swtchng\ loss} = \left(V * \frac{I_D}{2} * T_{on}T_{off}F_{SW}\right) + (C_{on\ loss} * V^2 * F_{SW})$$

$$P_T = P_{Swtchng\ loss} + P_{Conduction\ loss}$$

$$P_T = 75mW$$

Efficiency of Buck converter

Power output = 3W (3V@1A)

Input capacitor loss = 0.0108 W

Output capacitor loss = 4.5mW

Diode loss = 300mW

Inductor loss = 0.05 W

MOSFET loss = 75mW

Total loss = 440mW.

$$\eta_{converter} = \frac{P_{output}}{P_{output} + P_{Total\ loss}}$$

$$\eta_{converter} = \frac{3}{3 + 0.44} * 100$$

$$\eta_{converter} = 87\%$$

Vital Losses in Buck Converter are Conduction and Switching Losses. Here is a detailed cause of both of these-

Conduction losses are mostly dependent on:

1. Resistance during MOSFET’s conducting.
2. Forward voltage drop of diode
3. Winding resistance of inductor
4. Equivalent resistance of capacitor

Switching losses:

1. Volt-Ampere loss
2. Frequency difference losses
3. Reverse latency loss
4. Driving MOSFET gate losses
5. Controller consumption losses

3. IMPLIMENTATION & RESULTS

3.1 PV Cell Modelling

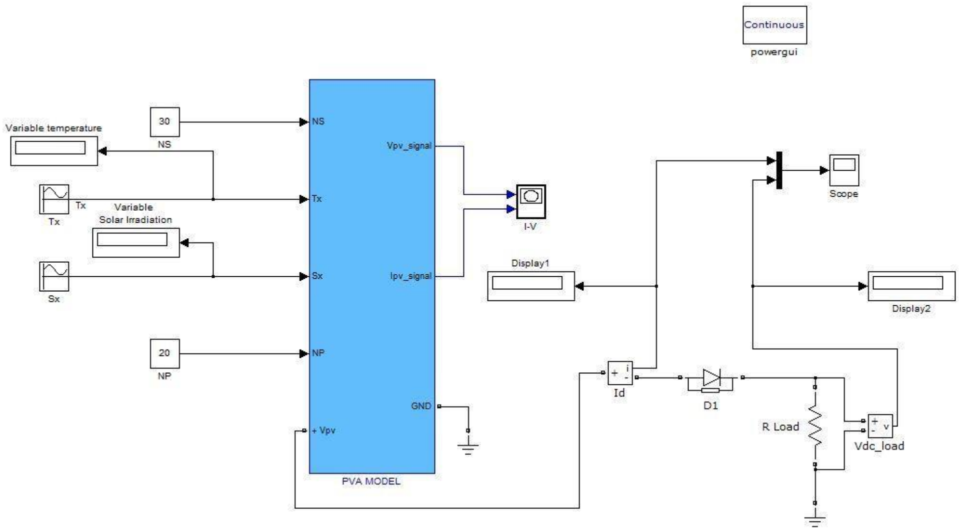


Figure 12 Simulink Block of PV Array Model

The PVA block consists of a single sub-block PV cell model which measures the performance of a single solar cell in the entire panel. The reference value of photocurrent I_{ph} at standard temperature T_c and solar irradiation S_c for the particular cell in use is used in the equation.

The PV cell model is the equivalent representation of a single solar cell. The solar cell simplified equation model within the PV cell model block diagram consists two sub-blocks – one to build the equation model and the other to account for the effects of temperature and solar irradiation on the performance of the cell.

The effect of radiation from sun and the rise or fall in temperature on the PV array/module has been shown and explained by the certain equations mentioned in the next page.

There are four constants whose values depends on the temperature and irradiation.

The temperature coefficients are C_{TV} and C_{TI}.

$$C_{TV} = 1 + \beta_T(T_C - T_X)$$

Where, β_T=0.004 and T_c=20°C (ambient temperature during the testing of cell).

$$C_{T1} = 1 + \frac{\gamma_T}{S_C}(T_x - T_c)$$

Where, γ_T=0.06.

The correction factors for accounting solar irradiation are C_{SV} and C_{SI}.

$$C_{SV} = 1 + \beta_T \alpha_S (S_X - S_C$$

Where, S_c is the reference solar irradiation obtained during cell testing a $\propto_S$=0.2 represents change in cell operating temperature's slope due irradiation level.

$$C_{SI} = 1 + \frac{1}{S_C}(S_X - S_C)$$

Using these correction factors, the new values of the output cell voltage is V_{CX} and photocurrent I_{phx} which are given by,

$$V_{CX} = c_{TV} C_{Sv} V_C$$

$$I_{phx} = C_{TI} C_{SI} I_{Ph}$$

Where, V_C and I_{ph} are the reference cell output voltage and current respectively obtained during standard cell testing.

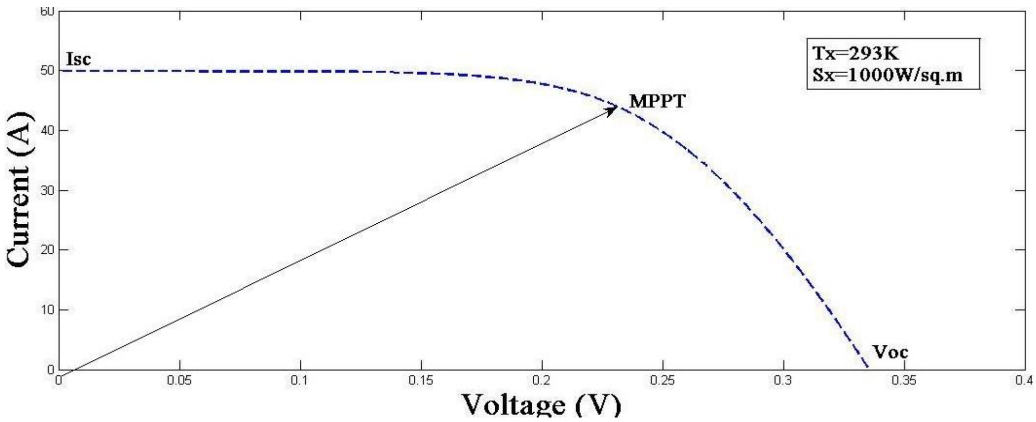


Figure 13 I-V Characteristics of a Solar Cell

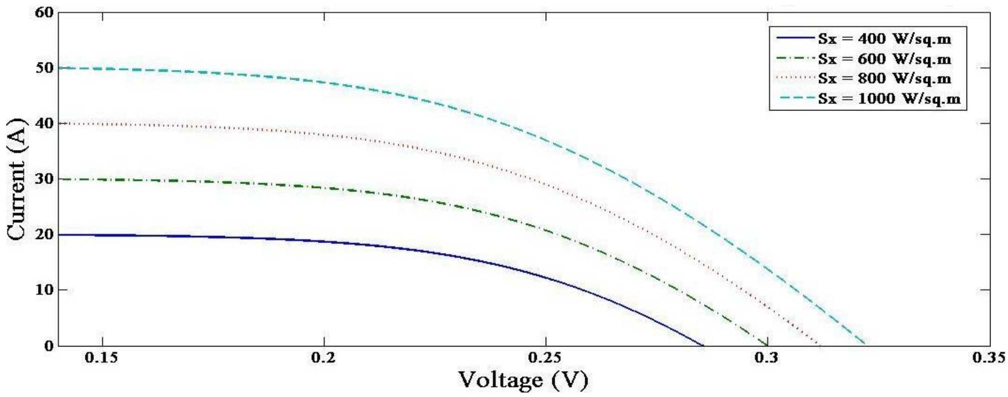


Figure 14 Variation of I-V Characteristics with Solar Radiation

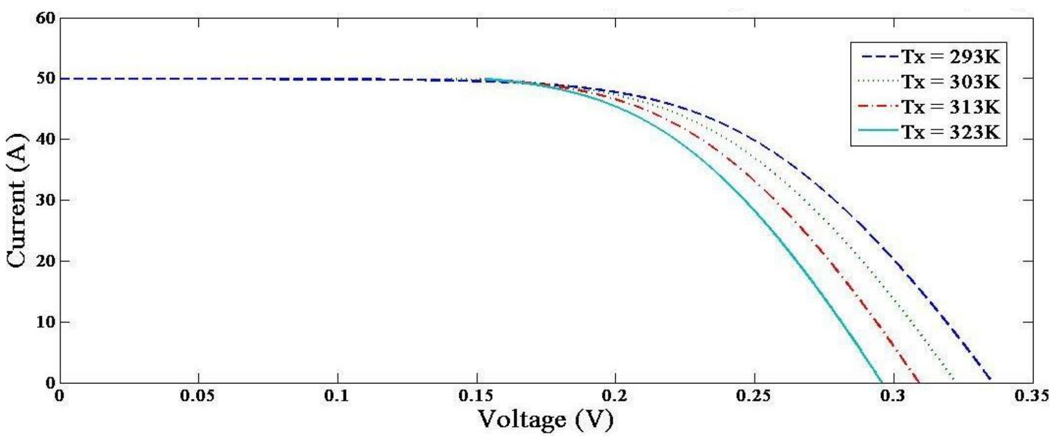


Figure 15 Variation of I-V Characteristics with Temperature

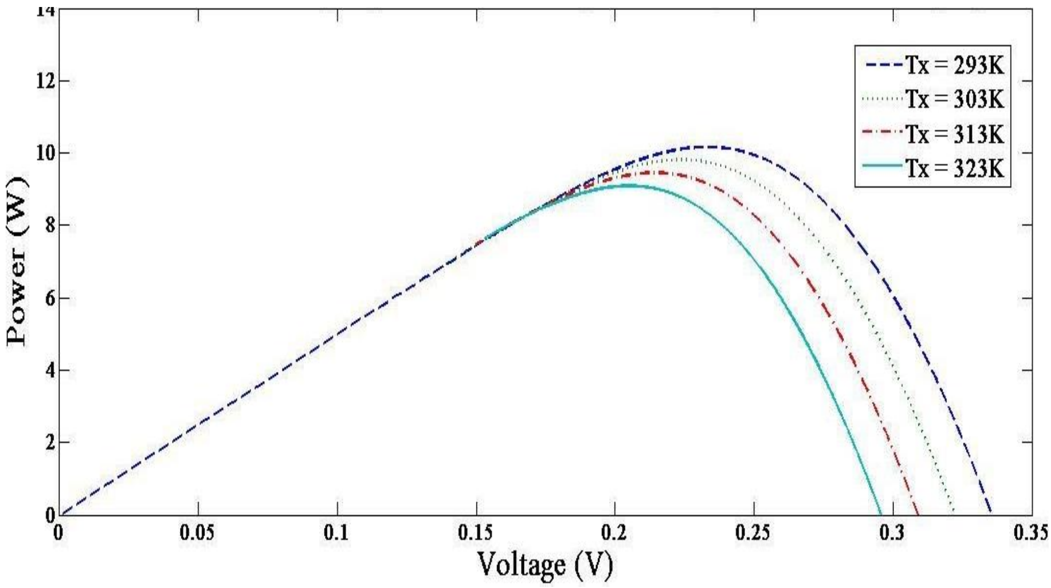


Figure 16 Variation of Output Power with Temperature

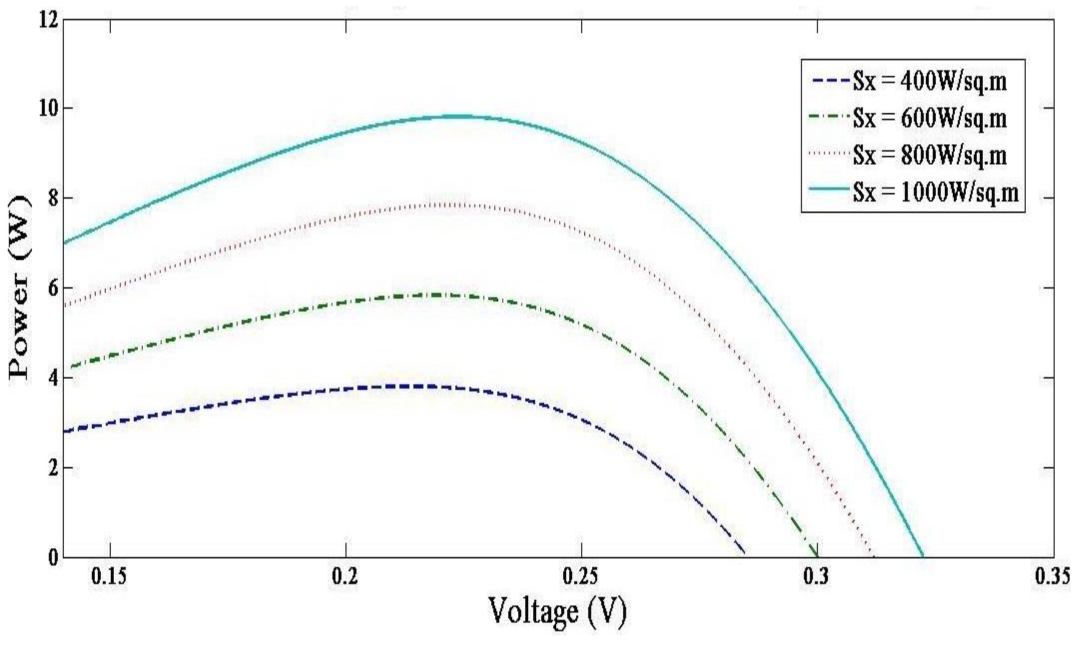


Figure 17 Variation of Output Power with Radiation

3.2 Charge Controller Using LM 2575

The LM2575 arrangement of controllers are solid incorporated circuits which give all the dynamic utilities to step down switching controller, equipped for dealing with a 1A load with great line and burden regulation. These chips can be readily accessible in constant output voltages of 3.3V, 12V, 15V and a customizable output form. Needing a few external parts, these controllers are easy to utilize and incorporate frequency compensator and a constant frequency oscillator. The LM2575 controller offers a good-proficiency substitution for prevalent 3-terminal linear controllers. It considerably diminishes span of heat sink, and much of the time heat sink is not needed. A typical arrangement of inductors optimised for utilization with LM2575 can be accessible from a few distinct manufacturers. This feature extraordinarily improves designing of switched-mode power supply. Other important attributes are an ensured g4% tolerance on voltage output in determined input voltage and output load condition, and g10% on frequency of the oscillator. Outside shutdown is incorporated, highlighting 50Milliampere (usual) standby current. The output switch incorporates cycle-to-cycle current restricting, and additionally thermal shutdown for complete protection under faulty condition.

3.2.1 Features

1 Modifiable within a large range (1.2 V to 37 V).

2 Straight forward and highly efficient Step-Down regulation (±4%).

3 Definite 1-Ampere Output Current.

4 Extensive Range of Input Voltage (4.75 V to 40 V).

5 Positive to Negative conversion property (Buck-Boost).

6 Uses easily obtainable Normal Inductors.

7 52KiloHertz constant Frequency Oscillator.

8 Shutting down ability with 50-mA Current.

9 Highly Efficient; as much as 88%.

3.2.2 Applications

1 Simple High-Efficiency Step-Down controller.

2 Pre-Regulator for Linear Regulators.

3 On-Card Switching Regulators.

4 Positive-to-Negative Converter (Buck-Boost).

3.2.3 Connection Details

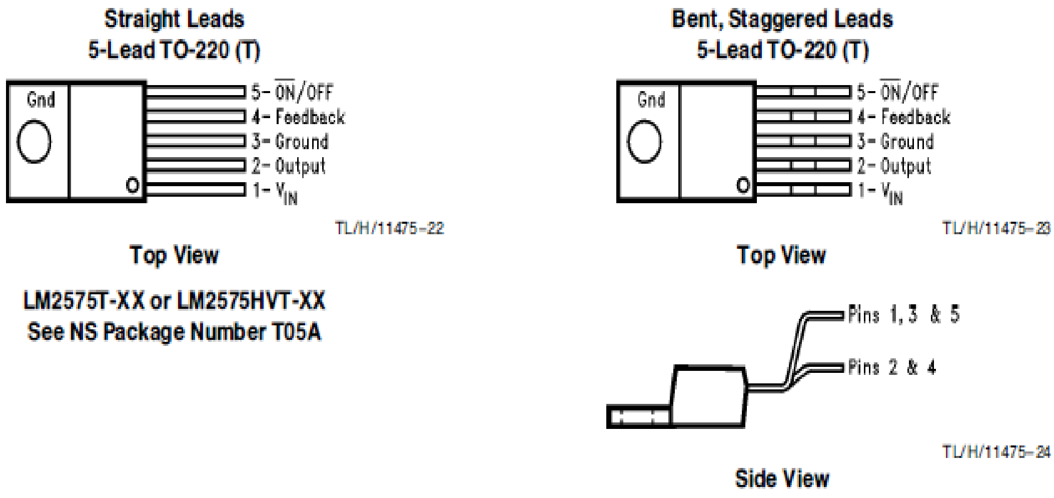
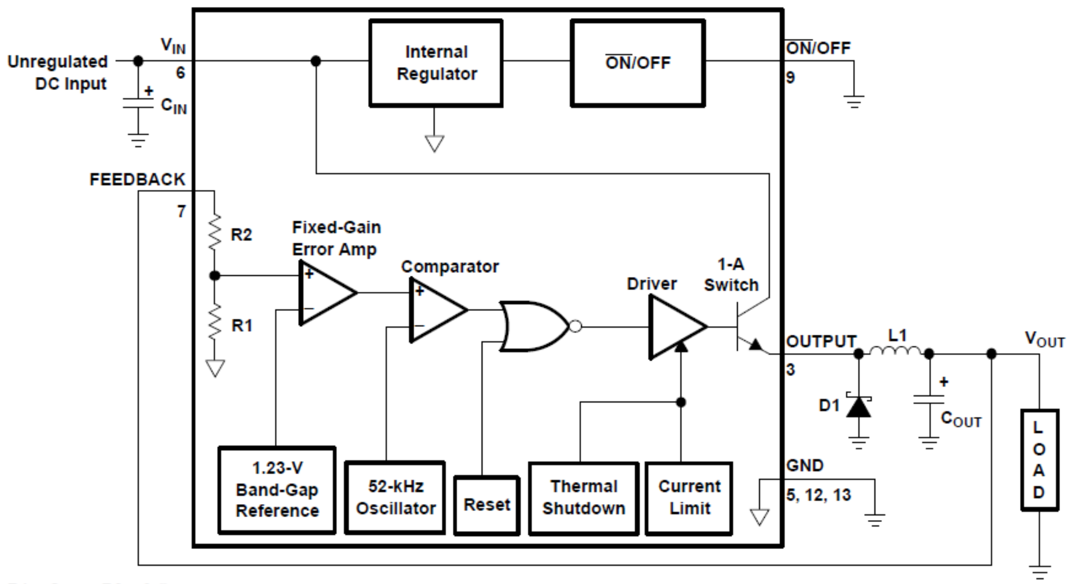


Figure 18 Connection Diagrams (XX Indicates output voltage option)

Typical Operating Characteristics

TA = 25°C (unless otherwise noted)



R1 = Open, R2 = 0 Ω

Absolute Maximum Ratings (1)

over operating free-air temperature range (unless otherwise noted)

		MIN	MAX	UNIT
V_{IN}	Supply voltage		42	V
	$\overline{ON}$/OFF pin input voltage	–0.3	V_{IN}	V
	Output voltage to GND (steady state)		–1	V
T_J	Maximum junction temperature		150	°C
T_{stg}	Storage temperature range	–65	150	°C

(1) Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

Package Thermal Data (1)

PACKAGE	BOARD	θ_{JC}	θ_{JA}
PDIP (N)	High K, JESD 51-7	51°C/W	67°C/W

(1) Maximum power dissipation is a function of T_J(max), θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) – T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.

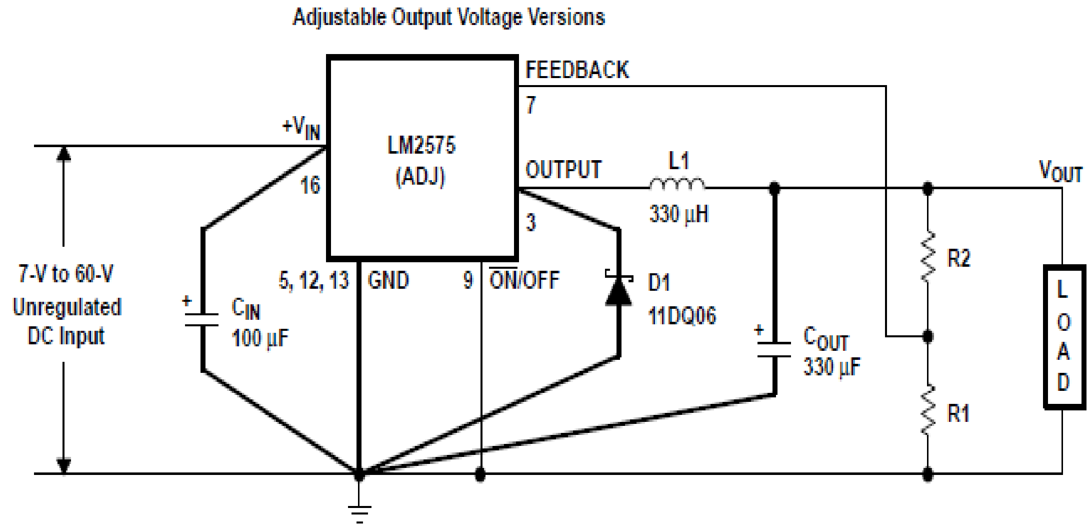
Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	MAX	UNIT
V_{IN}	Supply voltage	4.75	40	V
T_J	Operating virtual junction temperature	–40	125	°C

Figure 19 Functional Block Diagram

3.2.4 Layout Guidelines



$V_{OUT} = V_{REF}(1 + R2/R1) = 5\ V$

Where
$V_{REF} = 1.23\ V$
$R1 = 2\ k\Omega$
$R2 = 6.12\ k\Omega$

Figure 20 Layout Guideline of LM 2575

Considering all most all the switching regulator, an essential role is played by circuit layout in circuit performance. Parasitic inductances, wiring along with stray capacitances, are subjected to rapidly switching currents, which result in undesirable voltage transients. To minimize ground loops and inductance, the lead lengths denoted by heavy lines ought to be kept to a minimum. Optimal results are achievable by single-point grounding and also by ground-plane construction. Due to similar reasons, the two programmable resistors used in the adjustable version should be located as close as possible to the regulator in order to keep the sensitive feedback wiring short.

3.2.5 Circuit

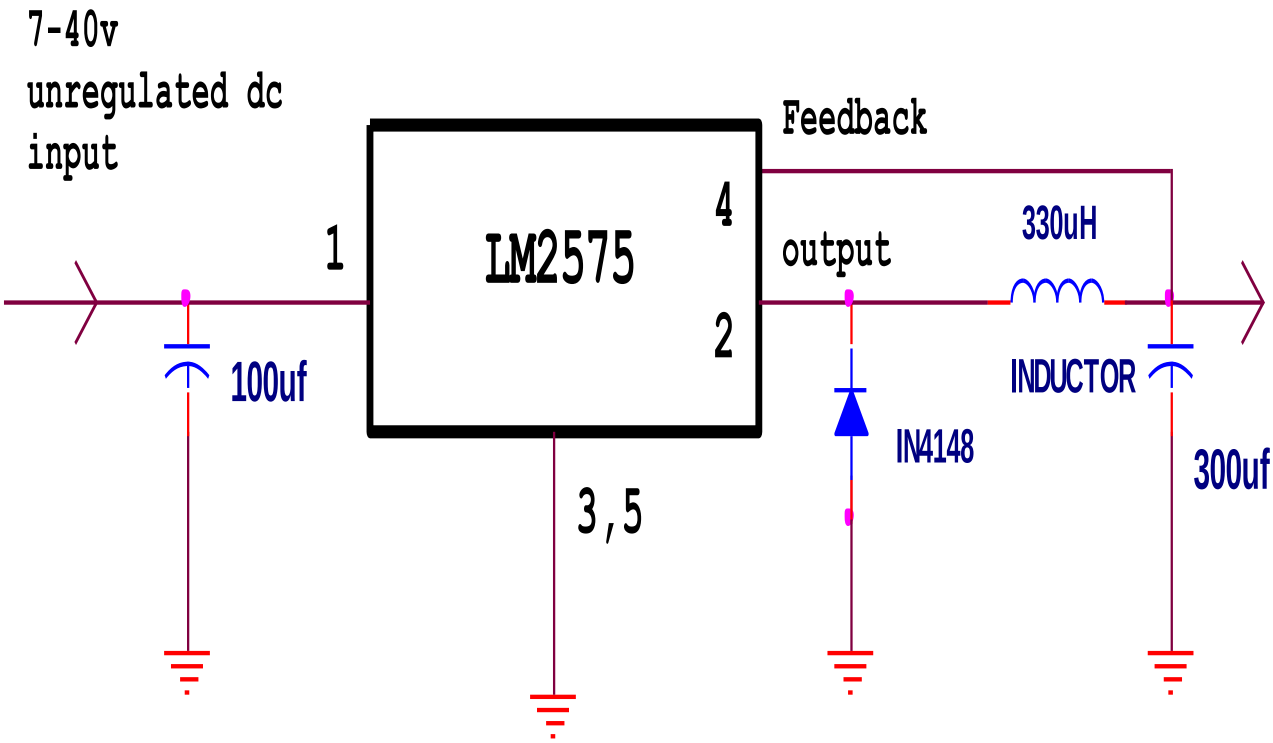


Figure 21 Circuit Diagram for LM 2575

3.3 Battery

The Dry cell can be a sort of chemical cells, ordinarily utilized now a days, as batteries, for some electrical machines. It was produced in 1887 by Yai Sakizō of Japan and was patented in 1892.

The dry cell utilizes glue electrolyte, along with sufficiently just dampness to permit current to pass. A dry cell is able work in any position without leaking, as it does not contain any free fluid, making it useable for versatile gear as compared to a wet cell.

By examination, the first wet cells are regularly delicate cut-glass holders with lead bars swinging from the exposed top and required watchful care to escape spillage. Lead-acid battery never attained to the security and versatility of dry cell until the recent improvements.

A typical dry cell is the Zn–C battery, with a nominal voltage of 1.5 volts, as same as the alkaline battery.

A normal dry cell involves a zinc as anode, for the most part as round and hollow pot, with a C cathode as a focal bar. The electrolyte is ammonium chloride as a glue alongside the anode. The residual space in between the electrolyte and C cathode is taken up by a second glue comprising of NH_4Cl and manganese dioxide, the recent going about as depolarizer. In a few outlines, the NH_4Cl is supplanted by $ZnCl_2$.

To start with, you will find out about the building square of all batteries, the CELL. The clarification will investigate the physical cosmetics of the cell and the techniques used to consolidate cells to give valuable voltage, current, and force. The science of the cell and how synthetic activity is utilized to change over compound vitality to electrical vitality are additionally examined. What's more, the concern, running, and operation of batteries, and also a portion of the wellbeing precautionary measures that ought to be taken after while working with and around batteries are examined. Batteries are generally utilized as sources of direct-current electrical energy in autos, vessels, air ship, ships, versatile electronic gear, and lighting hardware. In a few occasions, they are utilized as the main energy source; while in others, they are utilized as an auxiliary or standby energy source. A battery comprises of various cells gathered in a typical compartment and associated together to capacity as a source of electrical power.

The important parts of the battery are:

- Cell
- Electrode
- Electrolyte
- Container

3.3.1 Cell

A cell is a gadget that changes chemical energy into electrical energy. The earliest cell, known as galvanic or voltaic cell, is demonstrated in figure. It comprises of a bit of C and a bit of Zn deferred in a jug that has a mixture of water and sulphuric acid called the electrolyte.

The cell is key unit of battery. A basic cell comprises of two electrodes put in a holder that holds the electrolyte.

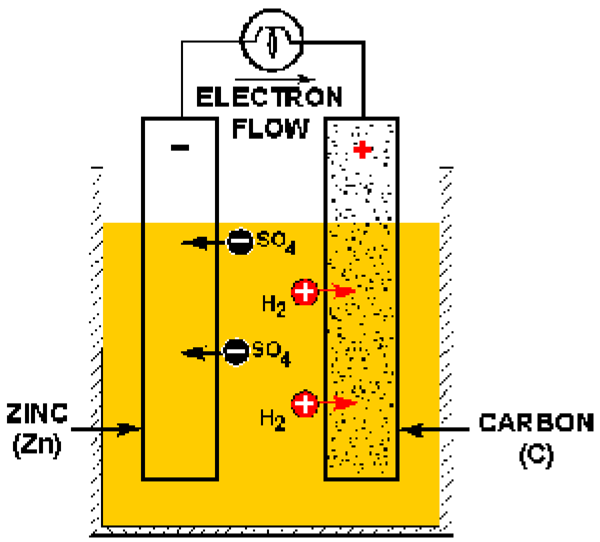


Figure 22 Simple Voltaic or Galvanic Cell

In a few cells the compartment goes about as one of the electrodes and, for this situation, is followed up on by the electrolyte.

3.3.2 Electrodes

The electrodes are materials which conduct and by these the current leaves or comes back to the electrolyte. In a simple cell, those are C and Zn strips that are put in electrolyte; while in dry cell, they are carbon pole in the middle and zinc holder in which the cell is amassed.

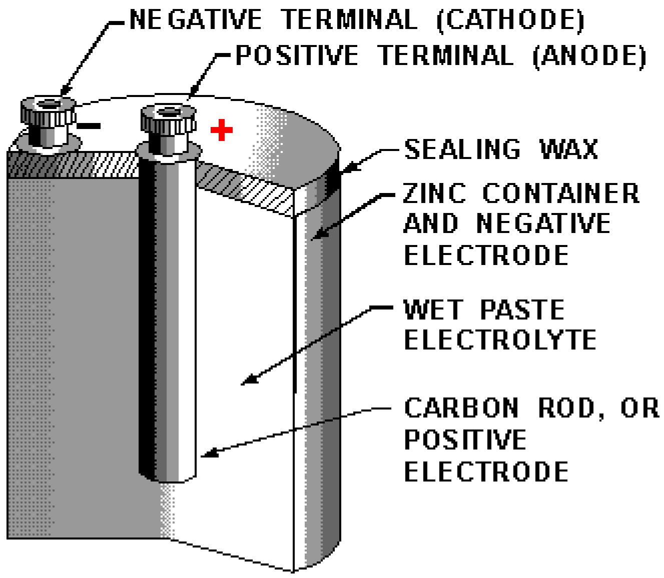


Figure 23 Dry Cell Cross Sectional View

3.3.3 Electrolyte

The electrolyte is a mixture of fluids that follows up on the electrodes. The electrolyte, which gives a way to electron stream, can be a salt, an acid or a basic solution. In the basic galvanic cell, the electrolyte is mostly in fluid form. Whereas in case of dry cell, the electrolyte is a glue.

3.3.4 Container

The container which may be made of one of various materials gives a method for holding (containing) the electrolyte. The container is additionally used to mount the electrodes. In the voltaic cell the container ought to be built of a material that won't be acted upon by the electrolyte.

4. CONCLUSION & FUTURE WORK

The modelling of the PV module is done. This mathematical modelling procedure serves as method to gain a deeper and comprehensive understanding of I-V and P-V characteristics of PV module and the obtained results are shown above.

Controller circuit is designed using LM2575 which acts as a charge controller for charging the 12V battery. It also check the energy flow into the battery once it is fully charged.

A DC-DC Buck Converter has been designed using MATLAB-Simulink environment which gives the required power for charging the mobile phone from the DC battery.

The developed prototype is charging any popular smartphone in 10-12 hours. The prototype is angled at 45 degree for optimal charging during all hours of daytime. The prototype is costly and is fixed structurally which leaves room to improvement in terms of its design and implementation. Also, another issue which can improved upon is the portability of the device so that it can be feasible economically and marketwise

References

1. Harus, L., Wiwiek, H., & Mochammad, S. (2015). The Effect of Using Current Stabilizer to the Dynamic Characteristic of a Regenerative Shock Absorber. *AMM*, *758*, 137-142. doi:10.4028/www.scientific.net/amm.758.137
2. Karanjkar, D., Chatterji, S., Kumar, A., & Shimi, S. (2014). Fuzzy adaptive proportional-integral-derivative controller with dynamic set-point adjustment for maximum power point tracking in solar photovoltaic system. *Systems Science & Control Engineering*, *2*(1), 562-582. doi:10.1080/21642583.2014.956267
3. Kandil, K., Altouq, M., Al-asaad, A., Alshamari, L., Kadad, I., & Ghoneim, A. (2011). Investigation of the Performance of CIS Photovoltaic Modules under Different Environmental Conditions. *SGRE*, *02*(04), 375-387. doi:10.4236/sgre.2011.24043
4. Ramasamy, M., & Thangavel, S. (2013). Experimental verification of PV based Dynamic Voltage Restorer (PV-DVR) with significant energy conservation. *International Journal Of Electrical Power & Energy Systems*, *49*, 296-307. doi:10.1016/j.ijepes.2013.01.018
5. Chung, I. (2011). A low-cost photovoltaic energy harvesting circuit for portable devices. *2011 IEEE Ninth International Conference On Power Electronics And Drive Systems*.
6. www.ti.com,. (2005). *LM2575-1-A SIMPLE STEP-DOWN SWITCHING VOLTAGE REGULATOR*. Retrieved 2015, from http://focus.ti.com/lit/ds/symlink/lm2575.pdf
7. Wikipedia,. (2015). *Solar cell phone charger*. Retrieved 10 May 2015, from http://en.wikipedia.org/wiki/Solar_cell_phone_charger